EFFECTS OF HOUSING BEEF COW-CALF PAIRS ON DRY LOT VS PASTURE ON COW PERFORMANCE AS WELL CALF PERFORMANCE AND BEHAVIOR THROUGH FEEDLOT RECEIVING

BY

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THESIS

Submitted in partial fulfillment of the requirements
for the degree of Master of Science in Animal Sciences
in the Graduate College of the
University of Illinois at Urbana-Champaign, 2019

Urbana, Illinois

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ABSTRACT

The objectives were to analyze the effects of housing cow-calf pairs in dry lots (DL) or pasture (PAST) on cow performance and reproduction and calf performance and behavior through the receiving phase. Simmental × Angus (n = 108; 87 ± 11.5 d postpartum) spring-calving cows were stratified by age, BW, BCS and calf sex and allotted to six groups. Cows were limit-fed a high energy ration to meet protein and energy requirements. Calves had ad libitum access to the same diet in an adjacent pen. Pairs on PAST were rotationally grazed with free-choice mineral. On d 0, cows were synchronized and artificially inseminated (AI). On d 0, 33, 55, and 90, BW and BCS were measured. Cow AI and overall pregnancy were determined on d 33 and 90, respectively. On d 55, milk production was determined using the weigh-suckle-weigh technique. At the age 87, 142, 177, 198 and 219 ± 11.5 d, calf BW was measured. Hair coat score (HCS) and dirty score (DS) were measured on d 0 and d 90. After weaning (177 ± 11.5 d of age) all calves were fed a diet consisting of corn silage, wet distiller grains, dry rolled corn and grass hay during the receiving phase (42 d). Calf behavior was observed after feedlot arrival. Average daily gain, DMI and feed efficiency were evaluated during the receiving phase. The data were analyzed using the MIXED procedure of SAS. Reproductive data were analyzed using GLIMMIX procedure of SAS. On d 0 and 33, cow BW did not differ ($P \geq 0.38$). On d 55, DL cows (682.8 kg) tended ($P = 0.07$) to have greater BW than PAST cows (654.0 kg). On d 90, DL cows (660.4 kg) had greater BW ($P = 0.05$) than PAST cows (628.6 kg). The BCS, milk yield and reproductive rates did not differ ($P \geq 0.12$). Dry-lot calves had greater ($P < 0.01$) BW and ADG prior to weaning. Calves from PAST had lower ($P < 0.01$) DS and HCS was not different ($P \geq 0.22$) at weaning. Upon feedlot arrival, more ($P < 0.01$) DL calves were walking and had increased ($P < 0.01$) vocalizations. Calves from PAST had greater ($P < 0.01$) ADG, DMI as a percent of BW, and gain:feed than DL calves during the receiving phase. Housing pairs in dry lots increased cow BW but did not affect BCS, milk production, and reproduction. Calves raised in a dry lot had greater BW and ADG prior to weaning, but PAST calves had fewer behavioral signs of stress and greater growth performance in the feedlot through the receiving phase.

DEDICATION

To my parents, Rodolfo (*in memoriam*) and Rosa Neira, my sister Ligia Neira and my wife, Fernanda Almeida Rabelo

ACKNOWLEDGEMENTS

There are several people I would like to thank for their support during my master's program. First, to Dr. Shike, Dr. McCann, and Dr. Parrett, thank you for your time and commitment to mentoring me and helping me with my research. Second, to all of my fellow graduate students; Adam Fritz, Parker Henley, Brady Klatt, David Crawford, Jack Oattes, Taoqi Shao, Becca Stokes, Sara Tondini, Mareah Volk, thank you for all of your help executing my research projects. To the crew at the ORR Beef Research Farm and Beef Research Farm, thank you for doing the daily requirements of feeding and doctoring all of the cattle on trial. Without everyone's help, none of this could have been possible.

Finally, I would like to thank my family for always being supportive and encouraging me to pursue my passion. Mom, Dad, and Ligia you have taught me that through hard work and dedication I can achieve anything. Fernanda, I thank you for trusting me by coming to Illinois and supporting me in my time here. These past years have been filled with hard work and joy, and I thank everyone that has helped me along the way.

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INTRODUCTION

Conventional beef cattle production has been suffering from the shortage of natural resources, decrease in labor availability and the needs of capital to expand the business. The Midwest region is considered fortunate for the abundance of feed resources. Moreover, the search for cropland has decreased the availability of grazing area and forage production. Alternatives will be needed if land price continues to increase or hold. Producers' interest in alternative systems using feedstuffs readily available has grown with the increase in pasture rentals and forage cost. Land price, feed availability, equipment sharing with row crop farm, and manure utilization make Midwest the epicenter for an alternative system.

TRADITIONAL COW-CALF SYSTEM

Grazing System

The conventional cow-calf system is characterized by maintaining cows on pastures and supplementing with minerals and vitamins to meet the nutritional requirements. The success of this system is dependent on the quality and availability of the grass throughout the year (Ball et al., 2007). Additionally, this system has been improved during the years using management strategies to intensify the producer's income. To reduce the necessity to store forages and the expenses of feeding, alternative systems of grazing must be applied. Stockpiling perennial grasses, using complementary forage systems with perennial and seasonal forages, and utilizing rotational grazing systems can increase the duration of grazing days up to 316 (Troxel et al., 2014). Furthermore, Beck et al. (2018) reported greater net return by hectare when intensified (0.4 ha/cow) grazing management was compared with conventional grazing (0.8 ha/cow).

Intensified grazing systems require additional labor and technical skills on forages and soil components. Consequently, economic conditions have encouraged cattle producers to explore alternative approaches to improve the profitability of cow-calf production.

Breeding Season

The implementation of a defined breeding season is important to match resource availability with cow requirements. Moreover, nutrition and reproduction are the two most important factors affecting the profitability of the operation (Hess et al., 2005). Improvements made during the past 50 years have demonstrated that to succeed in reproduction, it is important to keep cows in adequate energy balance.

Therefore, to maintain a cow in appropriate condition to become pregnant during the breeding season it is important that they have adequate body reserves at parturition so that the re-conception occurs in a short period (D'Occhio et al., 2019). However, for mature cows in lactation, the nutritional requirements increase and in the meanwhile postpone the re-initiation cyclicity (Diskin and Kenny, 2016).

Bulls are responsible to breed most of the cows on natural service in a ratio of 1:25 cows. The implementation of applied reproductive technologies such as artificial insemination, estrous synchronization, semen, and embryo cryopreservation into the production systems has enhanced the production efficiency (Lamb et al., 2016). The reproductive efficiency during the breeding season will determine part of the profitability of the total operation throughout the year.

Calving Season

In general, the producers match the calving season with greater pasture availability, because nutritional requirements increase with lactation. It is estimated that approximately 60% of the calves in the United States are born from February to April, the period referred to as the spring-calving season (NASEM, 2016). An early study conducted by Prichard and Marshall (1983), with first-calf heifers, reported that early-calving dams tend to be biologically and economically more efficient. In agreement, Feuz et al. (2006) found that when cow's requirements are matched with grass forage nutrients, there is potential to reduce the costs of production.

In order to assure a similar group of calves at weaning, it is essential to concentrate calving in a short period, consequently concentrating the labor. With the majority of calves being weaned in the fall, a shift in the calving season can be an economic strategy to increase income (Feuz et al., 2006). This strategy can be achieved by using crop residues and by-products to feed the herd since the greatest requirements of the cow will not be matched with the grazing period or by early-weaning to escape from the increased supply of calves in the fall.

Cow-calf Nutrition

Ruminants have the unique ability to convert low-quality forages into high-quality food for humans. The cow-calf industry is responsible for utilizing 50% of the total energy available in the beef industry, and 70% of the resources are used for maintenance of the cowherd (Ferrell and Jenkins, 1985). The production cycle of beef cows is approximately 12 months, and the nutritional requirement for the animals will vary according to each stage of production.

Nutritional status is one of the many factors that influence the production of the herd. A management practice that helps producers to follow the nutritional status of the herd is body condition score (BCS; Richards et al., 1986). The nutritional relationship between body energy reserve and cows performance was reviewed by Hess et al. (2005) where it was stated that prepartum nutrition is critical in determining the length of postpartum anestrus. Additionally, a BCS above 5 will ensure body reserves are adequate for postpartum reproduction, an adequate

BCS associated with a positive energy balance are critical for reproductive success (Hess et al., 2005).

Calving signifies the beginning of a new cycle of production. More importantly, the postpartum period has the highest nutritional demand due to cows being lactating and repairing the reproductive tract to be able to resume the heat cycle and breed. Furthermore, the NASEM (2016) reported an increase of 20 to 30% in energy requirements for lactating females when compared with non-lactating.

Lactation will change the requirements according to the amount of milk produced and the composition. Additionally, some authors (Romero et al., 1976; Smith and Baldwin, 1974) attribute the increase in requirements due to the expansion of the organ and tissues size as well vital organs (i.e. liver, mammary gland, lungs, rumen, and abomasum).

After the peak of lactation that is estimated at 50 to 65 days postpartum (Jenkins and Ferrell, 1984), the requirements decrease until the weaning day, when the calf has 5 to 8 months of age. Then, the requirement for a gestating cow is considered the lowest during the production cycle. Also, research has shown that this is the easiest time to put weight on cows and adjust the BCS to initiate a new cycle in adequate condition (D'Occhio et al., 2019).

However, 50 to 60 days before calving, also known as pre-calving period the nutritional requirements increase. There is an exponential growth pattern for the fetus and placenta, and also a direct relationship between gestational nutrient demands and calf birth weight (NASEM, 2016). In addition, a strategic supplementation during the last third of gestation can impact the offspring on greater weaning weights and helping heifers to achieve the puberty early in life (Funston et al., 2010; Martin et al., 2007).

Factors affecting the nutritional requirements

Some of the factors affecting the nutritional requirements in beef cows can be directly related to the physiological state, breed, age, sex, temperature, body weight and previous nutrition (NASEM, 2016). As the stage of pregnancy increases, the requirements also advance. Numerous publications indicate that the heat production increases nearly 50% at the end of the gestation and that maternal visceral tissues, liver, and gut are responsive to the stage of pregnancy, depending on the nutritional status (NASEM, 2016).

After the increase in body tissue during the last third of gestation and the increase in visceral organ mass, the maintenance requirements also increase. Ferrell and Jenkins (1985) showed that specialized functions such as greater lactation could be responsible for differences in maintenance between breeds. Following the previous model, researchers concluded that 23% of the variation between maintenance energy requirements between cows from different breeds was explained by differences in milk production (Montaño-Bermudez et al., 1990; van Oijen et al., 1993). Additionally, cows with increased genetic merit for milk production also have an increased dry matter intake during early lactation (Johnson et al., 2003), consequently compromising cows rebreeding in challenges environment.

Although it is difficult to make a direct comparison, differences between breeds in maintenance requirements have been reported since Armsby and Fries, (1911). In general, there are differences between types of breeds and the purpose of each one, where a dual-purpose can require about 20% more energy than beef breeds. Early research identified that *Bos indicus* breeds such as Nelore, are expected to have 10% less and crossbreds with British breeds (*Bos taurus*) had 5% lower maintenance that purebred British breeds (Rogerson et al., 1968). Conversely, recent research using Nelore data suggests that with genetic improvements and high rates of gain, the Nelore breed does not fit in the 10% group (Chizzotti et al., 2007; Tedeschi et al., 2002).

Age and sex also play an important role in nutritional requirements. Based on indirect evidence the NASEM (2016) does not recommend any adjustment in regarding of age in mature beef cows. Based on the ideas of Cartens et al. (1989b) and Turrel and Reynolds (1989), the requirements of maintenance is influenced by age, especially during the early life (15 to 81 weeks). Recent research has shown that although first-calf heifers and mature cows have the same digestibility and DMI (% of BW) during late gestation and early lactation, primiparous beef heifers were not able to consume the amount of forage necessary to support their requirements for maintenance, growth, and lactation (Linden et al., 2014).

Maintenance can also be impacted by the animals' body weight and body energy reserves. Empty body weight, normally referred as shrunk body weight (SBW) is a form to express the body weight without the fill. This value can be obtained by keeping the animal 18 h without food or by the equation BW × 0.96 (NASEM, 2016). This equation is provided to assist in the adjustments for body weight. To prove the effect of body energy reserve on the requirement of beef cows, Thompson et al. (1983) conducted research during the winter using crossbred Angus × Hereford and Angus × Holstein cows. They concluded that fat cows require less energy for maintenance due to better insulation provided by the subcutaneous fat.

The effects of the environment, temperature, and activity for grazing are also important factors in the regulation of the nutrients. Moreover, beef cattle control body temperature by heat dissipation, therefore when the air temperature is above the critical point, the body temperature becomes elevated, in consequence, the feed intake is compromised and maintenance requirement increase (NASEM, 2016). Similarly, in conditions with a temperature below the normal, environmental factors can cause an impact on thermoregulation, such as air movement, precipitation, humidity, and thermal radiation. Equally important, the grazing activity can increase the nutritional requirement. Animals that are required to graze have an increase of 10 to 20% in energy requirement, and this value can be 50% when the pasture is located in difficult terrains when compared with penned animals (NASEM, 1996).

Fetal Nutrition

The concept of fetal programming is defined as an effect in the offspring caused by alterations during gestation on the fetal development (Wallace, 1948). Numerous research has shown that the formation of the muscle fiber start to occur during the mid-gestation and is determined before birth. Indeed, the number of muscle fibers will define the muscle mass of the animal (Duarte et al., 2014).

Maternal nutrition has been pointed out as one of the main factors affecting the intra-uterine environment, delaying or enhancing fetal development (Du et al., 2010). To match the nutritional requirement of the cows during the gestation with the feed available is challenging. Therefore, it might be responsible for some of the complications observed in livestock animals, such as differing muscle fiber diameters, increased neonatal mortality, respiratory diseases and reduced meat quality (Wu et al., 2006).

During the first third of gestation, an important connection between the fetal placenta and the blood flow of the dam is formed to support the exponential increase in fetal growth (Reynolds and Redmer, 1995). The primary functional area of physiological exchanges between the maternal and fetal tissue is called placentome. Research has shown that nutrient restriction during early gestation can affect the placental angiogenesis and decrease the size and weight of placentomes when compared with control nutrition (Long et al., 2009; Vonnahme et al., 2007).

According to Robinson et al. (1977), about 75% of the growth in ruminants' fetus occurs during the last two months of gestation. The fetal period is crucial for muscle development. Therefore, a decrease in number of muscle fibers will negatively affect animal performance. Similarly, the fetal stage is responsible for intramuscular adipocytes, which has an impact on fat accumulation and consequently marbling in the carcass (Tong et al., 2009).

The muscle formation starts during the embryonic development still in the first third of gestation. A second stage in fetal development happens in the mid-gestation, and it is very sensitive to nutritional deficiency (Zhu et al., 2004). Considering the myofibers formation in two stages, Du et al. (2010) emphasize that the secondary myofibers partially overlaps with the formation of adipocytes and fibroblasts, which leads to producing the basic structure of the skeletal muscle. For that reason, adequate maternal nutrition during gestation is important to improve animal production efficiency.

Calf Nutrition

Calf weaning weight is largely responsible for the gross income in the cow-calf enterprise. The high correlation between the weaning weight and the ability of the dam to produce milk has been well documented (Knapp and Black, 1941). Interesting, at birth, calves are functionally considered a nonruminant. The development of the postnatal digestive system was described by Davis et al. (1998) to occur over three specific phases, starting with a pre-ruminant phase, where calves rely almost exclusively on milk, this phase finishes around three weeks of age. A transitional phase is described when the calf begins to eat some solid feed and goes until the weaning day, during this time occur the initiation of the fermentation in the reticulorumen that will lead to an evolution in the rumen epithelium (Drackley, 2008).

The third phase initiates at weaning and lasts the rest of the animals' life, it is called the ruminant phase, where the animal depends on the feed fermentation that will be absorbed in the form of volatile fatty acid (VFA), proteins and microbial mass will be responsible for providing the amino acids required (Davis and Drackley, 1998). Therefore, some of the strategies proposed by Rasby and Niemeyer (2011) to increase calf development to reach greater weaning weight are, increasing dams' milk production and increasing calf nutrient intake.

The relationship between cows with genetic potential to produce more milk and feed intake was studied by Jenkins et al. (1991), this research concluded that although cows with greater milk yield weaned heavier calves, more feed was required to maintain the body weight, thus were less efficient. Similarly, Mondragon et al. (1983) reported that in successive parities, fatter cows has reduced milk yield when compared to thin cows. A balance between the genetic potential for milk yield and the environment of production is extremely important for greater productivity.

Historically, creep feeding beef calves has consistently shown improved weaning weight of beef calves (Faulkner et al., 1994). Additionally, the use of this tool has shown effects not only during the suckling phase but also on post-weaning performance, carcass characteristics, and impacts on cow performance (Anderson et al., 1978; Myers et al., 2018; Tarr et al., 1994). The effect of the creep feed impacted not only the performance in finishing phase but also improved the carcass weight (18.5 kg) and ribeye size (4%) in Angus × Simmental steers (Shike et al., 2007).

Replacement heifers that had ad libitum access to creed feed for 84 d before weaning had 30% greater puberty percentage than heifers without creep feed (Buskirk et al., 1996). Conversely, Martin et al. (1981) identified effects on the progeny of cows creep-fed and concluded that detrimental consequences could occur and affect productivity in long-term, suggesting creep feeding terminal calves instead of replacement heifers.

INTENSIFIED COW-CALF SYSTEM

Initially, dry lots were considered a tool designed to help researchers to understand how to feed livestock animals. Thomas and Durham (1964), reported several studies that were conducted during early years feeding cows all-concentrate diets using dry lots throughout South Dakota, North Carolina, Texas, and other locations. Since that time, feeding cows in a pen was considered an alternative, making it possible for small operators to use the dry lot system to expand their production without having to purchase more land.

Traditionally the cow-calf industry is tied to the land by the availability of feed and forage, weather condition and geography. Some of the constraints on expanding cow-calf production are the high capital barrier, low availability of grazable acres and the aging of producers (NASEM, 2016). Moreover, most of these barriers increased due to the conversion of non-cropland to cropland and a higher land competition.

Historically, many of the cattlemen manage their cows in a confined system during the winter. It can be an efficient alternative to feed the herd while the pastures are not ready to be grazed. Also, it has been used as a management option during drought in some parts of the country or when the availability of pasture resources are low to avoid the liquidation of the cowherd.

Some of the main characteristics of confining beef cows are the low requirement for the area, greater marketability of crop residues and feedstuffs, flexibility to market animals, increased manure accumulation for fertilizing cropland, and nutritional control of the herd.

Undoubtingly, the intensification brings more challenges as a greater demand for labor and equipment for feeding and to spread the manure, greater level of management to control diets and more attention on contagious diseases are examples (Lardy et al., 2017).

Limit-feeding

The potential to control the intake and nutrition of the herd is considered one of the major advantages in intensified systems. The ability to adjust the nutritional needs of the cow to pregnancy and post-calving stage, and the ability to sort thin cows and adjust according to BCS is not an option for cows on pasture. The expenses with feed are the largest factor influencing profitability in the cow-calf industry (Miller et al., 2002). Limit-feeding is defined by Jenkins et al. (2015) as providing all the nutrients that a cow needs without providing everything that it can eat. When the price of corn is low, limit-feeding corn-based diets can be an option to decrease the cost of production during the winter or mid-late gestation and early lactation (Loerch, 1996; Schoonmaker et al., 2003). Additionally, the use of by-products and residues from the crop industry can aid in maintaining the cowherd in intensified systems.

Distiller grains have the great ability to supply protein up to 15% of the diet or energy when fed above 15% (Klopfenstein et al., 2008). The inclusion of co-products to limit-feed cows during lactation can reach 75% of the diet without detrimental effects (Shike et al., 2009). Moreover, when limit-fed cows were offered 120% of the metabolizable protein (MP) requirements during late gestation, the progeny presented greater carcass characteristics than progeny of cows limit-fed 100% of MP required (Wilson et al., 2016).

Intensified systems are estimated to decrease the nutritional requirement 10 to 20% (Sell et al., 1993). The addition of reduced requirement with crop production system can be an alternative to farmers to make more efficient use of their resources, especially labor, crop residues, and machinery. Moreover, additional advantages are related to controlling feed intake, reducing waste, and using TMR. Interesting, when round bales of hay were offered ad libitum in a fence-line feeder 40% was wasted (Miller et al., 2007). Similarly, when hay was limit-fed to cows by limiting the time of access to the bales, the waste was reduced in 52% compared with ad libitum (Lalman et al., 2015)

Monensin is commonly included in traditional feedlot diets, results in an increase in feed efficiency by decreasing dry matter intake and increasing average daily gain, decreasing the ruminal acetate to propionate rate and methane production. Recent research reported that limit-fed, pregnant heifers being treated with Monensin (150 mg/d) did not present large effect on energy and nitrogen balance, compared with control limit-fed heifers, but the methane production was lower for treatment heifers, the authors suggest a lack of energy saving when feeding heifers near the maintenance requirement, rather than ad libitum (Hemphill et al., 2018).

Bunk space is a critical factor on a limit-feeding system. Researchers recommend 0.6 m per cow in line bunk (Anderson et al., 2012). Also, when designing a new facility, it is important to take into account the size of the bunk so that more bulky rations can be offered, given the opportunity to use residues and coproducts (Jenkins et al., 2015).

Replacement and Reproduction

Intensifying the system of production can facilitate the implementation of biotechnologies in reproduction. Some of the advantages are easier and faster heat detection when cows are maintained in small areas, an easier synchronization and artificial insemination and a reduction in a number of bulls. When utilizing bulls with good libido in natural service, research has shown an increase of 10 to 25% in the number of cows bred in dry lot (Lardy et al., 2017). Interestingly, Floyd et al. (2018) compared the mounting behavior using HeatWatch of mature cows. The animals received a estrous synchronization protocol and were allotted on pasture or the dry lot, cows in dry lot were in estrous longer, receiving a greater amount of mounts in a shorter period than cows on pasture (Floyd et al., 2018).

Dryloting heifers has been a common alternative to improve BW of the animals before the breeding season. The consumption of diets with high concentrate inclusion before breading can decrease the age at puberty and impact the lifetime production since heifers that initiate the estrous cycles and conceive early have better chances to stay in the herd longer (Lesmeister et al., 1973; Marston et al., 1995).

It is important to match the environment where cows will be maintained with where heifers are developed. Olson et al. (1992) examined the influence of winter system on growth and reproductive performance of weaned heifers during the winter and subsequent summer. The animals were kept on dry lot or range with free access to hay. Animals in dry lot had greater gain during the winter, but heifers on pasture equalized the gains during the summer. The authors explain that the foraging skills acquired during the winter were important to help grazing heifers to achieve the same outcome. Perry et al. (2013) supports the idea and suggests a period of adaptation on pasture prior to the beginning of the breeding season to avoid nutritional changes that can have an influence on the uterine environment. The use of supplementation when moving heifers to pasture or retention of heifers in dry lot until after artificial insemination is performed are also management decisions that should be considered to maintain a steady BCS with satisfactory outcomes (Perry et al., 2015; Perry et al., 2016).

Ciccioli et al. (2005) conducted two experiments to investigate the effect of limit-feeding high (53.1%) or low (36.6%) starch diets for 30 or 60 days in dry lots and self-fed a diet with less (24.6%) starch on pasture to measure the puberty age at 60 days before the breeding season and consequently reproductive performance. The authors concluded that self-feeding low starch and limit-feeding high starch for 30 days was insufficient to increase performance and puberty at a lower age. Therefore limit-feeding heifers in dry lot with high starch can increase the results during the breeding season (Ciccioli et al., 2005). There are several alternatives that can be implemented to increase reproductive rates in an intensified system, the advantage of having cows closer to corral make it easier to implement the techniques and also to reapply if necessary.

Health

The intensified cow-calf system requires different settings for cattle, and it might have effects on health and well-being of the cows and calves. Managing risks requires greater understanding of the factors associated with hazards, how to mitigate those factors, and the associated costs (Moore, 1977). With animals being accommodated in pens it is expected that disorders will be spread faster. Therefore, it is important to have a strong sanitary calendar before starting the operation (Smith et al., 2003).

Some of the complications that might be found in an intensified system are related to behavior, feet and leg structure, and respiratory complications. Interestingly, a reduced mothering cow/calf bonding and colostrum intake were observed as the size of pen decreased (Kjæstad et al., 2001). Monitoring for foot and leg issues such as foot rot, hairy heel warts, and lameness are also important in this type of operation. Specialists recommend the bedding of pens to avoid problems with locomotion (Gunn et al., 2014). The cost of health remains an important financial constraint to most cattle producers, and therefore, an important consideration in the development of the intensified system (Smith, 2003).

Current research

Trubenbach (2014) used 32 pregnant cows that were blocked by days of gestation and stratified by BW in a 2 × 2 factorial design using a high-energy (2.45 Mcal ME/kg) or low-energy (1.94 Mcal ME/kg) ration that was fed at either 80 or 120% of estimated NRC maintenance requirement. This research concluded that feeding high energy ration, the requirement was lower than predicted, consequently reducing the amount of energy required to maintain a 545 kg cow by 23.5%. Therefore, even with the price per ton on as-fed basis being higher for a high-energy diet, with the reduction on the amount of DM required to maintain a cow on confinement, a lower cost per calorie delivered was achieved. In conclusion, the authors suggest to confine cows after weaning day up to 30 days prior calving, and recommend that for every cow confined during the period (4 months), 0.39 cows can be added for the remaining 8 months using the caloric energy saved (Trubenbach, 2014).

Preedy et al. (2018) evaluated the performance of cows and calves early (56 d) or conventionally weaned on pasture or dry lot environment. Cows from early-weaned treatment had a greater final BW and rump fat than cows conventionally weaned. However, no difference in performance was noticed from the environment (Drylot vs Pasture) where they were maintained. Interestingly, calves from Drylot presented greater performance and ADG independently of the weaning strategy (Preedy et al., 2018).

Gardine et al. (2018) conducted a study over three years in two different locations to evaluate the performance and viability of summer-calved cows in two different systems, grazing corn stalks or limit-fed in dry lot over the winter. Cows and calves on dry lot treatment had greater performance as well as the cows with greater BW and BCS, and calves with ADG greater than the cornstalk treatment. The researchers concluded that even with better performance, the gains were not enough to compensate the costs associated with the ration. Thus, wintering cows on cornstalks was identified as a more profitable system (Gardine et al., 2018).

Economic considerations

In cow-calf systems, profitability is highly associated with the price of feed and calves at weaning. Historically, commercial cow-calf producers focus on maximizing weaning weight and minimizing production costs (White et al., 2007). However, producers must address profitability with competitiveness, analyzing not only the financial costs, but also the opportunity of the investment to the cow-calf segment (McGrann and Richardson, 2003).

An intensified system requires a large investment in facilities and a higher level of management. White et al. (2007) suggests that cow-calf producers are exposed to the risk of the market when selling calves at traditional weaning sale point. To retain the ownership of the calves can be an opportunity to dilute the costs with structure of the farm.

An example of diluting costs with intensified system would be through selecting the feeding system. Braungardt et al. (2010) evaluated the costs of feeding methods to feed coproducts from the ethanol industry using formulas developed by the America Society of Agricultural Engineers. Machinery costs included interest, insurance, housing, repairs and maintenance. Costs were estimated for feed-wagon, grinder-TMR mixer and hand feeding for herds ranging in size from 50 to 300 animas. Interestingly, herd size was responsible for dictating which feeding strategy was the least expensive when the equipment necessary for feeding is factored into costs. It was more advantageous to hand feed in small herds, and the use of tractor and feed wagon become more economical as the size of the herd increased, free-choice hay was the most expensive method for large herds (Braungardt et al., 2010).

Anderson et al. (2012) compared the costs of maintaining cows year around in dry lot with six months grazing, feed cost per cow in the dry lot was $62 higher than pasture. The costs analyzed is counting for pasture rental rates but do not include fixed costs of facilities. Cost per pound of weaned-calf in dry lot was $1.02 and pasture system $0.79. Economic success of dry lot system is based on selecting competitively-priced feeds (Anderson et al., 2012). Combined system between dry lot during the summer and corn stalking grazing during the winter can help reduce the expenses when corn fields are close, and price of pasture is high. (Warner et al., 2015)

WEANING STRATEGIES

Under natural condition, weaning in beef cattle is a process where the milk yield of the dam starts to decrease gradually, and the intake of solid feed begins to increase by the calf. This shift in intake behavior causes a decrease in the bond between the cow and calf, and the total separation usually occurs naturally between 7 and 14 months of age (Enríquez et al., 2011). A commercial cow-calf producer focusses on maximizing weaning weight and minimizing production costs. Conventionally, the cow-calf producers apply the weaning process by separating the cow and calf without any preparation, and this abrupt system is also done at younger age (Hudson et al., 2010). Additionally, weaning the calf will also affect the body condition of the dam, which is very important for the reproductive performance and consequently more energy will be utilized for the developing fetus (Freetly and Nienaber, 2018).

Early-weaning and Creep-feeding

Many types of research have been conducted to evaluate the effects of early weaning beef calves. This strategy was initially based on the discovery that at 120 days of age, more than half of the calf's energy requirement comes from sources other than milk (Maddox, 1965). Early weaning can be performed with calves as young as 45 days of age, and the results will improve the herd performance with a greater reproductive performance by cows and increased cull cows marketing options (Rasby, 2007). Furthermore, early weaning was reported to be beneficial for young cows (3-yr-old), increasing the BCS and resulting in increased pregnancy rate (Arthington and Kalmbacher, 2003).

An alternative that is normally implemented when planning to early wean is creep feeding the calves. The composition of the feed can vary with region and type of ingredient available. Interestingly, steer calves offered a corn-based creep feed had greater quality grade and marbling than steers consuming soy-hulls (Faulkner et al., 1994). Similarly, when the age of weaning and type of feed were researched, Shike et al. (2007) reported improved carcass quality feeding high-concentrate diets and greater overall performance for calves early weaned and creep fed. Recent research evaluated the effects of diets containing DDGS or corn bran in early weaned and creep fed diets, and the authors showed that coproducts can be an alternative to replace corn on a diet with similar gains and greater profitability (Meteer et al., 2013). Overall, combining creep-feeding and early-weaning works as an alternative to increase the production of the cows and a supplemental tool to help calves to express the genetic potential for carcass traits.

Weaning Strategies

The conventional weaning strategy and mostly used by cow-calf producers is the abrupt weaning. Commonly this system is chosen due to the lower labor required and also because most of the times cow-calf producers prefer to send calves to be sold to a sale barn. The stress caused by weaning, marketing and transportation are the more significant contributors to the low performance of newly received feedlot cattle (Step et al., 2008). Based on the idea of animals presenting stress will decrease their intake, the immune system will also be compromised, enhancing the disease susceptibility (Haley et al., 2005).

Alternative strategies have been studied to minimize the effects of weaning beef calves. An approach that separates the pair by a fence for a few days before a definitive separation was used to allow partial physical contact while preventing suckling. Price et al. (2003) argued that signs of stress post-weaning can be due to the social separation, the termination of the milk feeding, or a combination of these factors and the results can be noticed as a decrease of eating and lying down and increased walking and vocalization. These authors noticed that when calves were weaned in treatments that provided total separation from cows and calves, higher levels of signs associated with distress were reported than the calves in fence line treatment (Price et al., 2003). In agreement, Smith et al. (2003) reported a reduction in behavioral postweaning stress with calves weaned at different ages (early and conventional) by maintaining dams within visual and auditory distance after three days.

Weaning calves in two stages is another alternative to minimize the adverse effects on the well-being of calves. This method is applied first by preventing calves from nursing with the aid of a plastic anti-suckling device (nose-flap) and later the separation of the pair. Haley et al. (2005) found positive responses with fewer signs of distress, but the authors advise about the importance to supply the required nutrition for this calves unable to suckle. Lippolis et al. (2016)

evaluated the effects of the two-stage method with nose-flap on cow performance and calf performance, behavior, and humoral immune response compared with traditional weaning methods. Nose-flap treatment did not improve performance and immune response postseparation from the dam when compared with conventional weaned calves (Lippolis et al., 2016).

Behavior at Weaning

In the production system, weaning is considered the most stressful moment for the calf. Some of the challenges will be caused by the loss of the mother and access to the udder and milk, and also changes in the social and physical environment (Enríquez et al., 2011). The milk yield of the cows was studied by Ungerfeld et al. (2009) to determine the effects on the behavior of the calves at six-month-old. The calves were observed during 1.5 h on 3 shifts daily from day -3 to day 5 from weaning. The research reported that calves from high milk yield cows tended to suckle more and spent less time grazing before and after the weaning than calves from low milk yield cows, showing that the amount of milk produced by the cow has effects on the behavior of calves (Ungerfeld et al., 2009).

The change in the environment is also a potential source of stress for calves after weaning. No research was found to support this hypothesis with beef cattle. However this research in other species such as deer fawns, foals and piglets showed that when these animals remained in the same place after weaning, the signs of stress were reduced (Church et al., 1999; Hötzel et al., 2011; Nicol et al., 2005). Research needs to be done with beef cattle maintaining the same environment where calves are raised to analyze the effects on behavior and performance. Although the impact of different weaning strategies was examined previously, Lambertz et al. (2015) investigated the effects of sex and age (6 or 8 months of age) of conventionally weaned calves on behavior and weight gain. As a result, young calves vocalized more on day 1, and females more than males. Also, young animals spent more time standing and walking, which supported the hypothesis that weaning at lower ages would pronounce more behavior distress (Lambertz et al., 2015).

Wiese et al. (2016) hypothesized that part of the decreased stress observed after conducting two-stage weaning is because the signs are split up in two stages, so the authors designed an experiment to compare the effects of methods of weaning on behavior. The treatments were 1) abruptly weaned calves 5 days prior transportation, 2) two-stage weaning using nose flaps applied 5 days prior transportation, and 3) abruptly weaned at the transportation. Interestingly, the response observed on behavior of two-stage weaned calves were more intense than calves weaned at transportation, but still lower than calves abruptly weaned prior transportation. This study shows that two-stage strategy will minimize the behavioral indicators of stress, but it not a stress free system (Wiese et al., 2016). Recently, Rauch et al. (2018) evaluated the effects of two-stage weaning and injectable trace mineral on receiving cattle growth performance and behavior. Two-stage weaning decreases the behavior signs associated with stress and the use of injectable trace minerals six days before weaning tended to increase the ADG regardless of weaning strategy (Rauch et al., 2018).

Receiving Phase

Newly weaned calves are usually challenged by stresses associated with transportation, change in the diet, and new social environment when commingling. Research has been done to recommend producers to retain the calves for a short period (Cole, 1985). These events lead to multiple physiological, nutritional and immunological changes in the calf (Loerch and Fluharty, 1999).

The process of weaning, marketing, and transportation that may happen between these two processes will result in deprivation from water and feed. The effects of providing water or feed at arrival, or both were analyzed in early research and the results showed that there were no differences between the treatments and producers should provide water as soon after arrival as possible (Preston, 2007). Two of the feeds that are usually offered for calves at the receiving are almost exclusive hay and corn silage on the first day, the process of adaptation for diets with concentrate starts after that stepping up with higher amount in short period of time and goes to 4.5 to 13.5% of roughages in finishing diets (Galyean and Defoor, 2003). Preston and Kunkle (1974) compared the effects of receiving calves on hay diet or corn silage, the intake reported by calves on hay was higher in the first week, but the calves on corn silage ate more and performed better at the end.

Another challenge for calves at receiving is the immunological status of this calves. The stress of these animals and the environment that they are exposed to are directly involved with the appearance of health problems as bovine respiratory disease (BRD). The damage caused by the necessity to treat the animals can reduce the profits up to $291.93 in calves treated 3 or more times compared with the ones not treated (Fulton et al., 2002). An important factor that contributes to BRD infestation is the frequency of vocalization. The greater the frequency of vocalization, the greater the susceptibility of calves to get infected. Additionally, an environment with mud, manure, poor air quality, and a new social dominance order and new pathogens can cause much more damage for the operation (Loerch and Fluharty, 1999).

Arthington et al. (2008) evaluated the effects of different preweaning management systems on the performance of transported steers during a 30 day receiving phase. The treatments were: 1) weaned at the day of transportation (control), 2) creep-feeding free-choice concentrate before weaning, 3) preweaning and providing a concentrate on pasture, or 4) early weaning at 70 to 90 days of age and kept on pasture, the control group was weaned and transported in the same day. Calves early weaned had improved performance, a significant part of this difference can be explained by the stress factor suffered during the other treatments. Boyles et al. (2007) and Mathis et al. (2008) showed that when compared with dry lot preconditioning, calves preconditioned on pasture yield improved health during the finishing phase.

CONCLUSION

It is well known that cow-calf producers traditionally base their production systems on grazing. Managing beef cows in an intensified system requires greater management skills that can present a multitude of potential advantages and concerns. The success of this system will be driven by increased efficiency while minimizing expenditure. Price of pasture land will continue to grow in future years, thus, exploring the efficacy of an intensified system is necessary.

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CHAPTER 2: EFFECTS OF HOUSING COW-CALF PAIRS ON DRY LOT VS. PASTURE ON COW PERFORMANCE AND REPRODUCTION, AND CALF PERFORMANCE AND BEHAVIOR THROUGH THE RECEIVING PHASE

ABSTRACT

The objectives were to analyze the effects of housing cow-calf pairs in dry lots (DL) or pasture (PAST) on cow performance and reproduction and calf performance and behavior through the receiving phase. Simmental × Angus (n = 108; 87 ± 11.5 d postpartum) spring-calving cows were stratified by age, BW, BCS and calf sex and allotted to six groups. Cows on DL were limit-fed a high energy ration to meet protein and energy requirements. Calves had ad libitum access to the same diet in an adjacent pen. Pairs on PAST were rotationally grazed with free-choice mineral. On d 0, cows were synchronized and artificially inseminated (AI). On d 0, 33, 55, and 90, BW and BCS were measured. Cow AI and overall pregnancy were determined on d 33 and 90, respectively. On d 55, milk production was determined using the weigh-suckle-weigh technique. At the age 87, 142, 177, 198 and 219 ± 11.5 d, calf BW was measured. Hair coat score (HCS) and dirty score (DS) were measured on d 0 and d 90. After weaning (177 ± 11.5 d of age) all calves were fed a diet consisting of corn silage, wet distiller grains, dry rolled corn and grass hay during the receiving phase (42 d). Calf behavior was observed after feedlot arrival. Average daily gain, DMI and feed efficiency were evaluated during the receiving phase. The data were analyzed using the MIXED procedure of SAS. Reproductive data were analyzed using GLIMMIX procedure of SAS. On d 0 and 33, cow BW did not differ ($P \geq 0.38$). On d 55, DL cows (682.8 kg) tended ($P = 0.07$) to have greater BW than PAST cows (654.0 kg). On d 90, DL cows (660.4 kg) had greater BW ($P = 0.05$) than PAST cows (628.6 kg). The BCS, milk yield and reproductive rates did not differ ($P \geq 0.12$).

Dry-lot calves had greater ($P < 0.01$) BW and ADG prior to weaning. Calves from PAST had lower ($P < 0.01$) DS and HCS was not different ($P \geq 0.22$) at weaning. Upon feedlot arrival, more ($P < 0.01$) DL calves were walking and had increased ($P < 0.01$) vocalizations. Calves from PAST had greater ($P < 0.01$) ADG, DMI as a percent of BW, and gain:feed than DL calves during the receiving phase. Housing pairs in dry lots increased cow BW but did not affect BCS, milk production, and reproduction. Calves raised in a dry lot had greater BW and ADG prior to weaning, but PAST calves had fewer behavioral signs of stress and greater growth performance in the feedlot through the receiving phase.

INTRODUCTION

The expansion of beef cow-calf operations in the Midwest has been limited due to increasing land values and decreased pasture availability. Consequently, cow-calf producers are looking for alternative production systems. The increase in acres dedicated to crop production has decreased the availability of acres available for grazing and forage production. Concurrently, the expansion in the ethanol industry has resulted in increased availability of grain coproducts. Producer interest in alternative systems using readily-available feedstuffs has increased with the expansion in pasture rentals and forage cost. Land price, feed availability, equipment sharing with row crop enterprise, and manure utilization make the Midwest the epicenter for an alternative system.

Historically, livestock systems such as poultry, swine, and feedlot cattle have passed through intensification; the cow-calf industry could be the next. Intensification is necessary to increase production within the confines of the limited land and resource availability. Semi-confinement and extended dry-lot housing are potential alternate systems. Maintaining cows on dry lots is not a new concept for the cow-calf system (Thomas and Durham, 1964); the majority of Midwest beef cattle producers are familiar with these systems as they are utilized in the winter throughout the Midwest. Commonly, cow-calf producers feed harvested or purchased feed throughout the winter and this practice has historically served as an alternative during times of limited pasture availability or quality during the winter months (Miller et al., 2007). Research conducted on wintering beef cows in dry lot demonstrated that limit-feeding hay, crop residues, and co-products from the ethanol industry can be an option to maintain the herd (Braungardt et al., 2010; Faulkner et al., 2012; Shike et al., 2009). For producers wanting to expand, it is logical to utilize these existing systems and strategies and extend their use into the summer months.

Although we know how these systems work for housing dry cows and short-term housing of pairs, limited data is available on the impact of extended housing in these systems on cow-calf pairs. Extensive evaluation of the impacts on cow and calf performance, health, and welfare is needed. We hypothesized that housing beef pairs on dry-lots would have an improvement on cow performance and the calves would be better adapted to the feedlot environment and consequently display fewer behavioral signs of stress during the receiving period resulting in improved growth performance. Therefore, the objective of this research was to determine the effects of housing cow-calf pairs on dry lots and compare with pasture on cow performance and reproduction, and calf performance and behavior through the receiving phase.

MATERIALS AND METHODS

All experimental procedures were approved by the Institutional Animal Care and Use Committee of the University of Illinois and followed the guidelines recommended in the Guide for the Care and Use of Agricultural Animal in Agricultural Research and Teaching (FASS, 2010).

Animals, Experimental Design and Treatments

To evaluate the effects of housing beef pairs on dry lots vs pasture on cow performance and reproduction as well as calf performance and behavior through the receiving period, 108 spring-calving (87 ± 11.5 d postpartum), Angus × Simmental cows (BW = 670 ± 83.7 kg) and their progeny were evaluated for 85 d at the Orr Agricultural Research and Demonstration Center in Baylis, IL. Prior to the initiation, cows were wintered and calved in dry-lots and fed ad-libitum.

A stratified, randomized design was used. Cows were stratified by age, BW, BCS, calving date, and sex of the calves and allotted to six groups. Groups were randomly assigned to 1 of 2 treatments: dry lot (**DL**) or pasture (**PAST**). Cows on DL were maintained in 33.0- x 10.7-m concrete lots with a 3 7 x 7-m open-front shed and their calves had access to a creep pen that was 11.0- x 10.7-m concrete lot with a 7 x 7-m open-front shed. The open-front area was bedded on day 35 of the treatment period using wheat straw to prevent problems of locomotion on cows. Dry-lot cows were limit-fed a TMR (**Table 1**). Calves were fed the same diet as cows on ad-libitum basis in the adjacent creep pen. (**Table 2**).

Cow-calf pairs on PAST were managed on a rotational grazing system stocked at 0.22 ha/pair and animals were rotated biweekly. Pastures were comprised of a mix of red clover (Trifolium pretense), white clover (Trifolium repens), and endophyte-infected fescue (Festuca arundinacea). Composition of the pasture can be found in Figure 1. The pairs on PAST had access to a free choice inorganic mineral (ORR Beef HI-MAG cattle mineral; Pike Feeds; Pittsfield, IL), formulated to meet or exceed requirements (NASEM, 2016).

Prior to the initiation of the project, cows were assigned to a 7 d CO-Synch + CIDR protocol as outlined by (Grussing et al., 2016), and artificially inseminated (AI; 86 ± 17 d postpartum). Ten days following AI, cows were exposed to bulls for a 44 d breeding season. Conception to AI and overall pregnancy were determined at 33 and 91 d post-AI, respectively. Conception to AI and overall pregnancy rates were determined by a trained technician via ultrasonography (Aloka 500 instrument (Wallingford, CT); 7.5 MHz general purpose transducer array).

Sample collection and analytical procedures

Cow and calf BW were collected at the initiation of the trial (d 86 and 87 ± 11.5 postpartum), at intermediate point (142 ± 11.5 d postpartum), and weaning (d 176 and 177 ± 11.5 postpartum). Two-day full BW were taken prior to feeding at initiation. Five days prior to weaning, PAST treatment were placed on dry lots for five days of common diet. Hay (CP 9%; NDF 63%) was fed ad-libitum to both treatment groups. Calves on DL treatment were still fed TMR with free access to hay as well. Hair coat scores (**HCS**; 1 to 5, in which 1 = slick, short coat and 5 = unshed, full winter coat), and BCS [emaciated = 1; obese = 9; as described by Wagner et al. (1988)] were evaluated and recorded at 86, 142 and 176 ± 11.5 d postpartum. Milk production was estimated using the weigh-suckle-weigh (**WSW**) technique at 142 ± 11.5 d postpartum (Beal et al., 1990). Twenty-four-hour milk production was measured, and milk samples were collected from a sub-set of 12 cows per treatment (4 per pen).

Locomotion scores were also collected before the start of the common diet (81± 11.5 d postpartum) from cows on a 3-point scale, where 1 = acceptable, 2 = moderately lame, and 3 = severely lame (Simon et al., 2016). During the trial, animals identified as moderate or severely lame were treated, percentage of animals treated per treatment can be found on table 4. Dirty score (1 = clean, and 5 = very dirty; Greenough and Vermunt, 1991) was also done by a trained observer at the initiation of the treatment, at the end of the treatment and at arrival in the feedlot.

At weaning, calves were weighed and shipped 271.9 km to the University of Illinois Beef Cattle and Sheep Field Research Laboratory in Urbana, IL. Upon arrival, calves were weighed again. Pre-trucking and arrival weights were used to calculate a percent BW shrink for each calf. Calves were sorted by sex and treatment and assigned to 12 pens [8-9 steers per pen and 7-9 heifers per pen (4.88 m × 10.36 m)] in the same barn on opposite sides. The barn was constructed of a wood frame with a ribbed metal roof and with siding on the north, west, and east sides. The south side of the barn was covered with polyvinyl chloride–coated 1.27 by 1.27 cm wire mesh bird screen and equipped with retractable curtains for wind protection. Pens had slatted concrete floors covered by interlocking rubber matting. Calves from each treatment were separated by 8 empty pens to minimize influence on behavior. Calves were fed in concrete feed bunks with 0.4 m/calf of bunk space. Day 0 to d 42 is referred to as the receiving period. Calves were offered ad-libitum access to a receiving diet (**Table 3**). Calves were weighed again on d 21, 41, and 42, and final BW for all calves was determined by averaging a 2-d consecutive BW on d 41 and 42. Incidences of morbidity were recorded by animal care personnel daily throughout the duration of the trial.

Ingredient samples were collected biweekly from DL and were composited for analyses. Forage samples from PAST treatment were hand-clipped at the initiation of the experiment. Samples of forage were collected at the initiation of grazing and as cows were removed from pastures; samples were composited in 4 time-points to represent a month of grazing. Forage samples were dried in a 55°C forced air oven for 3 d and then ground with a Wiley mill (1-mm screen, Arthur H. Thomas, Philadelphia, PA). Forage samples were analyzed for neutral detergent fiber (**NDF**) and acid detergent fiber (**ADF**; using Ankom Technology method 5 and 6, respectively; Ankom200 Fiber Analyzer, Ankom Technology, Macedon, NY), ether extract (**EE**;

using Ankom Technology method 2; Ankom XT10 Fat Analyzer, Ankom Technology), **CP** (Leco TruMac, LECO Corporation, St. Joseph, MI), and ash (600° C for 2 h ; Thermolyne muffle oven Model F30420C, Thermo Scientific, Waltham, MA).

During the receiving phase, feed ingredient samples were collected on d 0, 21, and 42. Feed bunks were cleaned to measure feed refusal every week during the receiving phase. Feed refusals were then weighed and aliquots were taken to be dried in order to determine dry matter (**DM**) content. The amount of dried refusal was subtracted from the amount fed to determine the intake.

Behavior was observed on d 1 and d 2 of receiving phase for 12 h. Cattle were fed at 0600 and calf behavior was observed from 0700 to 1900 on both days. Behavior was observed every 15 minutes. The number of steers lying, standing, walking, and eating were recorded, and activities were not mutually exclusive (steers could be standing and eating). Pens were sampled for vocalizations during 2 minutes for each treatment with 15 minutes interval. Any audible vocal sound that could be attributed to a specific calf was counted as a vocalization. Volunteers from the University of Illinois Department of Animal Sciences were used to observe cattle behavior. Volunteers were blind to the treatment of the calves.

Statistical Analysis

The MIXED procedure of SAS 9.4 (SAS Inst. Inc., Cary, NC) was utilized to analyze all variables excluding cow reproductive performance, locomotion, and percentage of animals limping. Pen was used as the experimental unit. Fixed effects included treatment, calving date, and cow age in the model statements for all variables for cows. The sire and sex were included as a fixed effect in the models for all variables pertaining to calf performance. For DMI, data was analyzed as repeated measurement, and treatment, week and treatment by week were included as fixed effect. The REPEATED statement was used to model the repeated measurements within pen for each variable and the variance components covariance structure was used for DMI. Least square means function of SAS was used to separate treatment means. The GLIMMIX procedure (SAS Version 9.4, SAS Inst. Inc., Cary, NC) was utilized to analyze cow reproductive performance (AI conception rate and overall pregnancy rate) and percentage of cows treated and limping using binomial distributions. Significance was declared at $P \leq 0.05$ and trends will be discussed at $0.05 < P \leq 0.10$.

RESULTS AND DISCUSSION

Cow Performance

Cow BW and BCS data are reported in Table 4. Cows on DL tended ($P = 0.07$) to be heavier at time of WSW and were heavier ($P = 0.04$) than cows maintained on PAST at time of weaning. This difference in BW did not result in a change in cow BCS either at the WSW ($P = 0.55$) or at weaning ($P = 0.73$). This change in BW was not surprising as the cows on DL were limit-fed a ration to maintain BW and BCS. However, cows on PAST treatment lost BW during the preweaning period. This change in BW can be explained by the rain fail deficit (Figure 1) that occurred that was responsible for reducing the availability and quality of the pasture (Figure 2). Holloway et al. (1979) observed that DMI was lower for lactating beef cows grazing low quality (39.7% ADF) pasture when compared with high quality (37.9% ADF) from April to September. In this experiment, initial pasture ADF was 33.4%, but with the drought limiting the development of the plants, the final ADF was 39.5%. In contrast, Preedy et al. (2018) reported cow-calf pairs maintained on pasture improved BW change (-33.7 kg), compared to cows limit-fed on dry lot (-48.4 kg). Additionally, cows on native pasture were heavier than cows dryloted year around receiving poor ad-libitum hay (Deutscher and Slyter, 1978). Cow performance is dependent on the quality of the diet, having an appropriate pasture or feeding a diet of quality on dry-lot will ultimately dictate cow performance.

Milk Production, Milk Composition, and Reproductive Performance

Cow milk production, milk composition, and reproductive performance are shown in Table 5. Milk production did not differ ($P = 0.13$) between treatments. Milk composition was different ($P = 0.01$) for milk urea nitrogen (MUN); PAST cows had greater MUN than DL. No differences were observed for the remaining components analyzed ($P = 0.59$). Elevated MUN is often observed when cows are in a negative energy balance and are mobilizing body reserves. The elevated requirement for lactation combined with the low quality of the pasture likely resulted in negative energy balance. Baker et al. (1995) reported an average of 15 to 16 md/dL of MUN on lactating cows with balanced diet, therefore, the values observed in this project are still in an acceptable range.

No differences ($P = 0.46$) in AI conception rate between DL (81.6%) and PAST (72.4%) cows were observed. Similarly, the overall pregnancy rate did not differ ($P = 0.34$). Results are ilustrated on Figure 3.

Hair Coat Score, Dirty Score, and Locomotion Score

Hair coat score, dirty score, and locomotion score are displayed in Table 6. Hair coat score was greater ($P = 0.01$) for PAST cows at the end of the treatment. Cows in the DL treatment were able to shed better than cows on PAST. During the treatment period, it was common to observe cows in the DL scratching against the fences and also licking each other more frequently than on PAST. Cows on DL were limit-fed and typically were done eating within 45 to 60 minutes. Also, the quality of the pasture was lower than expected due to the deficit of rain. The PAST cows were grazing endophyte-infected fescue and potentially were experiencing fescue toxicity. Recent research demonstrated that cows grazing infected tall fescue had rough hair coats (Mayberry et al., 2017).

Despite HCS being different for cows, calves did not differ (P = 0.22) at the beginning or end of the treatment. The dirty score was greater for DL calves (P = 0.01) at the end of the treatment, and at the arrival in the feedlot (P = 0.01). The amount of mud in the pen and the dirtiness of animals can decrease the feed efficiency by 25% (Grandin, 2016). The dirty score is also considered a method of assessing the welfare of animals in a feedlot. Although the difference was significant, it is still considered a clean score (Greenough and Vermunt, 1991; Earley et al., 2015). The authors initially did not chose to bed the pens because cows were being limit-fed and the bedding could be ingested during the transition from ad-libitum.

Additionally, there were no differences in the percentage of lame cows (P = 0.23) or treated (P = 0.20). Housing cows on concrete has been associated with dairy cows exhibiting locomotion problems. Vanegas et al. (2006) found that cows housed on concrete were 5 times more likely to be diagnosed as lame as those housed on rubber mats over concrete. Initially, DL treatment was maintained on pens without bedding, but as the problems started to appear with a greater number of cows limping, the pens were then bedded to provide better well-being for the DL animals. It is important to note that both treatments wintered and calved on dry lots prior to the start of this project, and the results observed on both treatments could be an outcome from the previous environment.

Preweaning Calf Performance

Calf BW and ADG are shown in Table 7. Dry lot calves were heavier (P = 0.04) at the WSW and at weaning (P = 0.04). Additionally, DL calves had greater ADG (P = 0.01) than

PAST during the preweaning period. Burson (2017) studied the effects of cows calving on pasture, confinement, and sandhills system on health and performance of calves until weaning. Conversely, pasture treatment had greater BW and ADG at weaning than calves raised in confinement. Holloway et al. (1979) also observed an increase of 18 kg for calves grazing on high quality pasture. Clearly, the PAST calves could have had improved performance if the drought had not affected the environment. Previous research demonstrates that when calves on dry lot have access to creep, they usually are heavier than calves on pasture or on dry lot without creep (Deutscher and Slyter, 1978; Faulkner et al., 1994; Meiske and Goodrich, 1969; Perry et al., 1974).

Behavior Observation

Behavior observation (Table 8) was analyzed during twelve hours for two consecutive days at feedlot arrival. On day one, the percentage of animals standing (P = 0.29), eating (P = 0.27), walking (P = 0.61), and lying (P = 0.29) was not different between treatments. Interestingly, the calves from DL vocalized more (48 vs 33 times per head/h; P = 0.01) than PAST calves. On day 2, more calves from DL were observed walking (P = 0.01), and standing (P = 0.04), consequently, fewer calves were observed lying (0.04). More vocalizations per hour were assigned to DL calves than PAST calves on day two (17.5 vs 7.7; P = 0.01).

The results observed during the behavior observation is not what the authors had hypothesized for this experiment. Initially, the expectation was that calves raised in dry lots would adapt better to the new environment, with fewer signs of stress during the receiving due to previous exposure to small pens and eating TMR from a feed bunk. The authors speculate that the drought condition during the preweaning phase could have affected the relationship between the pairs on the PAST by naturally weaning the calves before the weaning day. It is also documented that the breaking of the bond between cow and calf is more relevant to the behavior of the calves than the loss of access to milk (Wiese et al., 2016). The DL calves had always been in close proximity to their dams.

Previous studies have documented the frequency of vocalization plus the increased behavioral stress with excess walking can lead to an increased susceptibility to respiratory tract infections (Loerch and Fluharty, 1999). During this research, no observations of morbidity or respiratory problems from either treatment was observed. Stěhulová et al. (2017) also observed that calves with higher ADG vocalized more then calves with inferior ADG at the weaning. Fast growing calves received greater supply as greater milk and consequently, nurses with greater frequency, different from calves that nurses less and have less to lose through the weaning (Ungerfeld et al., 2009; Stěhulová et al., 2013).The behavioral events observed during the first two days in this experiment are in agreement with Jensen (2018), that described the behavioral signs normally observed on beef and dairy calves at the weaning.

Receiving Calf Performance

A treatment by time effect was observed for DMI ($P < 0.01$; Table 9), PAST calves ate more ($P = 0.03$; 4.9 vs 4.2 kg/d) during the first week of the receiving phase. Feed efficiency did differ ($P = 0.01$) in favor of PAST calves as well. Additionally, the increased feed efficiency observed from PAST calves was similar to two-stage weaned calves following the weaning when compared to conventional weaned counterparts (Haley et al., 2005). Moreover, a similar intake was observed by Faulkner et al. (1994) when comparing calves that received ad-libitum creep feed or limited creep with control no creep calves. However, Shike et al. (2007) noticed greater DMI and G:F on normally weaned calves receiving creep feed than control treatment. These results demonstrate that calves from PAST were compensating from the preweaning phase where the development was limited by the drought period and the conditions of the pasture. This data supports the point that PAST calves transitioned better to the feedlot environment.

Receving calf performance are displayed in Table 10. As expected, BW was different ($P = 0.01$) at the arrival in the feedlot. Although the difference between the treatments reduced from 41 to 31 kg during the receiving phase, BW was still different ($P = 0.01$) at the end of the receiving period. During the first half of the receiving period, ADG did not differ ($P = 0.17$), but during the second half, PAST calves gained more ($P = 0.02$) than DL calves, and also had greater gain overall during the receiving phase ($P = 0.01$). Deutscher and Slyter (1978) observed greater BW for pasture calves than dry lot calves in the feedlot, but ADG did not differ. Ungerfeld et al. (2009) observed a difference in feeding and ruminating behavior of calves weaned from high and low milk dams. Calves from low milk spent more time eating and ruminating before and after weaning than calves from high milk yield cows. The authors speculates that calves from PAST may have been partially weaned by the cows at the time of the weaning due to the drought.

In conclusion, housing beef pairs in dry lots increased cow BW but did not affect BCS, milk production, and reproduction. Calves raised in a dry lot had greater BW and ADG prior to weaning, but PAST calves had less behavioral signs of stress and greater growth performance in the feedlot. Dry lot systems are an alternative for cow-calf producers to utilize readily available feedstuffs and increase the size of the herd. Over the last decade, incorporation of drylot systems into beef production has increased exponentially. More research is required to fully understand the effects of these production systems.

TABLES AND FIGURES

Table 1. Dry lot ration composition and proximate analysis

	Inclusion, DM basis		
Item	d 0	d 14	d 50
Ingredient, kg			
Corn silage	7.71	7.26	-
DDGS[1]	3.18	3.40	3.40
Corn stalks	2.72	1.36	4.08
SBH[2]	-	-	2.27
DRC[3]	-	-	3.27
Supplement[4]	0.41	0.41	0.41
Analyzed nutrient content			
DM, %	64	63	85
CP, %	13.1	9.0	11.2
NDF, %	38.1	38.7	51.0
ADF, %	17.9	14.9	26.8
Extract ether, %	5.1	3.3	3.1

[1]Dried distillers grains with solubles

[2]Soybean hulls

[3]Dry Rolled Corn

[4]Supplement contained 87.7% ground corn, 8.9% limestone, 1.8% trace mineral salt [8.5% Ca as calcium carbonate, 5% Mg as magnesium oxide and magnesium sulfate, 7.6% K as potassium chloride, 6.7% Cl as potassium chloride, 10% S as S8, prilled, 0.5% Cu as copper sulfate and Availa-4 (Zinpro Performance Minerals; Zinpro Corp, Eden Prairie, MN), 2% Fe as iron sulfate, 3% Mn as manganese sulfate and Availa-4, 3% Zn as zinc sulfate and Availa-4, 278 mg/kg Co as Availa-4, 250 mg/kg I as calcium iodate, 150 mg/kg Se as sodium selenite, 2,205 KIU/kg VitA as retinyl acetate, 662.5 KIU/kg VitD as cholecalciferol, 22,047.5 IU/kg VitE as DL-α-tocopheryl acetate, and less than 1% crude protein, fat, crude fiber, salt], 0.1% Rumensin 90 (198 g monensin/kg, Rumensin 90; Elanco Animal Health, Greenfield, IN), and 1.5% fat

Table 2. Ration intake for dry lot treatment during the preweaning phase

	Ration		
Item	Transition	With Silage	Without Silage
Days	14	35	36
Cow			
DMI[1], kg/d	15.5	13.6	12.5
DMI as %BW[2], %	2.3	2.0	1.9
Calf			
DMI[1], kg/d	-	1.3	2.6
DMI as %BW[2], %	-	0.7	1.4

[1]Dry matter intake
[2]Dry matter intake as percentage of the body weight. Average body weight from the period was used

Table 3. Ingredient and nutrient composition of receiving diet on dry matter basis

Item	Receiving[1]
Ingredient, %	
Dry rolled corn	15.0
Modified distillers grains	18.0
Corn silage	15.0
Hay	42.0
Supplement[2]	10.0
Analyzed nutrient content	
Crude Protein, %	10.6
NDF,[3] %	40.8
ADF,[4] %	20.6
Extract ether, %	3.1

[1]Backgrounding diet was provided from d 0 to 42

[2]Supplement contained 76.2% ground corn, 15.9% limestone, 6.0% urea, 0.91% trace mineral salt (trace mineral salt = 8.5% Ca as CaCO3, 5% Mg as MgO and MgSO4, 7.6% K as KCl2, 6.7% Cl as KCl2 10% S as S8 [prilled], 0.5% Cu as CuSO4 and Availa-4 [Zinpro Performance Minerals; Zinpro Corp, Eden Prairie, MN], 2% Fe as FeSO4, 3% Mn as MnSO4 and Availa-4, 3% Zn as ZnSO4 and Availa-4, 278 mg/kg Co as Availa-4, 250 mg/kg I as Ca(IO3)2, 150 Se mg/kg Na2SeO3, 2,205 KIU/kg vitamin A as retinyl acetate, 662.5 KIU/kg vitamin D as cholecalciferol, 22,047.5 IU/kg vitamin E as dl-α-tocopheryl acetate, and less than 1% CP, fat, crude fiber, and salt), 0.155% Rumensin 90 (198 g monensin/kg Rumensin 90; Elanco Animal Health, Greenfield, IN), 0.1% Tylosin 40 (88 g tylan/kg Tylosin 40; Elanco Animal Health), and 0.75% soybean oil

[3]Neutral detergent fiber

[4]Acid detergent fiber

Table 4. Influence of dry-lot housing vs. pasture on cow BW and BCS

	Treatment[1]			
Item	DL	PAST	SEM	*P*-value
Cows	54	54		
BW, kg				
Initial[2]	690	687	12.6	0.87
WSW[3]	683	654	11.9	0.07
Final[4]	660	628	11.5	0.04
BW change	(22.2)	(54.4)	6.0	0.01
BCS				
Initial[2]	5.8	5.9	0.11	0.63
WSW[3]	5.8	5.8	0.13	0.55
Final[4]	5.6	5.6	0.43	0.73
BCS change	(0.1)	(0.2)	0.12	0.42

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system.
[2]Performance reported 87 ± 11.5 d postpartum
[3]Weigh-Suckle-weigh milk production measured 142 ± 11.5 d postpartum.
[4]Performance reported 177 ± 11.5 d postpartum

Table 5. Influence of dry-lot housing vs. pasture on cow milk production, milk composition, and subsequent reproduction

	Treatment[1]			
Item	DL	PAST	SEM	*P*-value
Milk production,[2] kg/d	9.34	6.92	1.27	0.13
Milk composition[3]				
Fat, %	3.12	3.01	0.60	0.86
Protein, %	2.82	2.86	0.15	0.79
Lactose, %	4.56	4.77	0.37	0.60
Total Solids	11.40	11.55	0.59	0.81
MUN[4], mg/dL	6.7	13.3	1.21	0.01

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2]Determined by Weigh-Suckle-weigh milk production measured 142 ± 11.5 d postpartum
[3]Determined from 12 cows per treatment
[4]Milk urea nitrogen (MUN).

Table 6. Influence of dry-lot housing vs. pasture on hair coat score, dirty score, and locomotion

Item	Treatment[1] DL	PAST	SEM	*P*-value
HCS[2], 1 - 5				
Cow, Initial[3]	2.6	2.2	0.22	0.15
Final[4]	1.2	1.8	0.12	0.01
Calf, Initial[5]	2.5	2.2	0.15	0.11
Final[6]	2.0	1.8	0.13	0.22
Calf dirty score[7]				
Initial[5]	1.4	1.3	0.13	0.32
End of treatment[6]	1.7	1.0	0.10	0.01
Receiving[8]	1.8	1.3	0.09	0.01
Cow locomotion				
Lame[4,9], %	48	32	-	0.23
Treated[10], %	47	14	-	0.20

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2] Hair coat scores (HCS; 1 to 5, in which 1 = slick and 5 = unshed)
[3]Evaluated at 87 ± 11.5 d postpartum
[4]Evaluated at 172 ± 11.5 d postpartum
[5]Evaluated at 87 ± 11.5 d of age
[6]Evaluated at 172 ± 11.5 d of age
[7]Determine by a 5-point scale (1 = clean, and 5 = very dirty (Greenough and Vermunt, 1991))
[8]Evaluated at 177 ± 11.5 d of age
[9]Determine by a 3-point scale (1 = acceptable, 2 = moderately, and 3 = severely (Simon et al., 2016)) where scores > 1 were considered lame
[10]Cows treated at least one time for problems related to locomotion

Table 7. Influence of dry-lot housing vs. pasture on calf body weight (BW) and average daily gain (ADG) during the suckling phase

Item	Treatment[1] DL	Treatment[1] PAST	SEM	*P*-value
n, pen	3	3		
BW, kg				
Initial[2]	140.9	138.2	3.38	0.52
WSW[3]	201.2	184.3	5.83	0.04
Final[4]	259.5	217.7	6.12	0.01
ADG, kg/d				
Initial-WSW	1.10	0.85	0.05	0.01
WSW-Final	1.48	0.81	0.07	0.01
Initial-Final	1.31	0.88	0.04	0.01

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2]Performance reported 87 ± 11.5 d of age
[3]Weigh-Suckle-weigh milk production measured 142 ± 11.5 d of age
[4]Performance reported 177 ± 11.5 d of age

Table 8. Influence of dry-lot housing vs. pasture on calf behavior during the receiving phase

	Treatment[1]			
Item	DL	PAST	SEM	*P*-value
n, pen	3	3		
Day 1 Behavior[2]				
Standing, %	61.7	64.5	2.55	0.29
Lying, %	11.8	14.5	2.33	0.27
Walking, %	38.3	35.5	2.55	0.29
Eating, %	7.6	6.9	1.39	0.61
Vocalizations, calf/h	47.6	32.7	4.9	0.01
Day 2 Behavior[2]				
Standing, %	44.5	38.8	2.51	0.04
Lying, %	17.2	18.6	1.45	0.37
Walking, %	55.5	61.2	2.51	0.04
Eating, %	4.2	1.9	0.64	0.01
Vocalizations, calf/h	17.5	7.6	2.2	0.01

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2]Behavior as percentage of calves observed for each behavior category from 0700 to 1900

Table 9. Influence of dry-lot housing vs. pasture on dry matter intake (DMI) and DMI as % of BW during the receiving phase

	Treatment[1]			*P*-value	
Item	DL	PAST	SEM	Treatment	Trt × time[2]
DMI, kg/d					< 0.01
Week 1	4.25	4.90	0.23	0.02	
Week 2	6.25	5.88	0.27	0.20	
Week 3	6.32	5.88	0.26	0.13	
Week 4	6.61	6.62	0.29	0.96	
Week 5	6.90	7.07	0.38	0.66	
Week 6	7.36	7.85	0.34	0.18	
DMI as %BW[3], %					
d 0-21	2.02	2.37	0.08	0.01	
d 21-42	2.27	2.67	0.10	0.01	
d 0-42	2.17	2.54	0.08	0.01	

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2]Treatment by time interaction
[3]Dry matter intake as percentage of the body weight. Average body weight from the period was used

Table 10. Influence of dry-lot housing vs. pasture on calf body weight (BW) and average daily gain (ADG) during the receiving phase

	Treatment[1]			
Item	DL	PAST	SEM	*P*-value
n, pen	3	3		
BW, kg				
d 0	259.51	217.76	6.12	0.01
d 21	294.10	254.36	6.65	0.01
d 42	318.09	286.78	6.03	0.01
ADG, kg/d				
d 0-21	1.62	1.76	0.08	0.17
d 21-42	1.14	1.54	0.10	0.02
d 0-42	1.38	1.65	0.05	0.01
G:F				
d 0-21	0.292	0.315	0.02	0.39
d 21-42	0.164	0.214	0.01	0.01
d 0-42	0.221	0.258	0.01	0.01

[1]Drylot (DL) system, and Pasture (PAST) cattle on rotational grazing system
[2]Shrink calculated as percentage of difference from final BW during the preweaning phase and BW at receiving phase

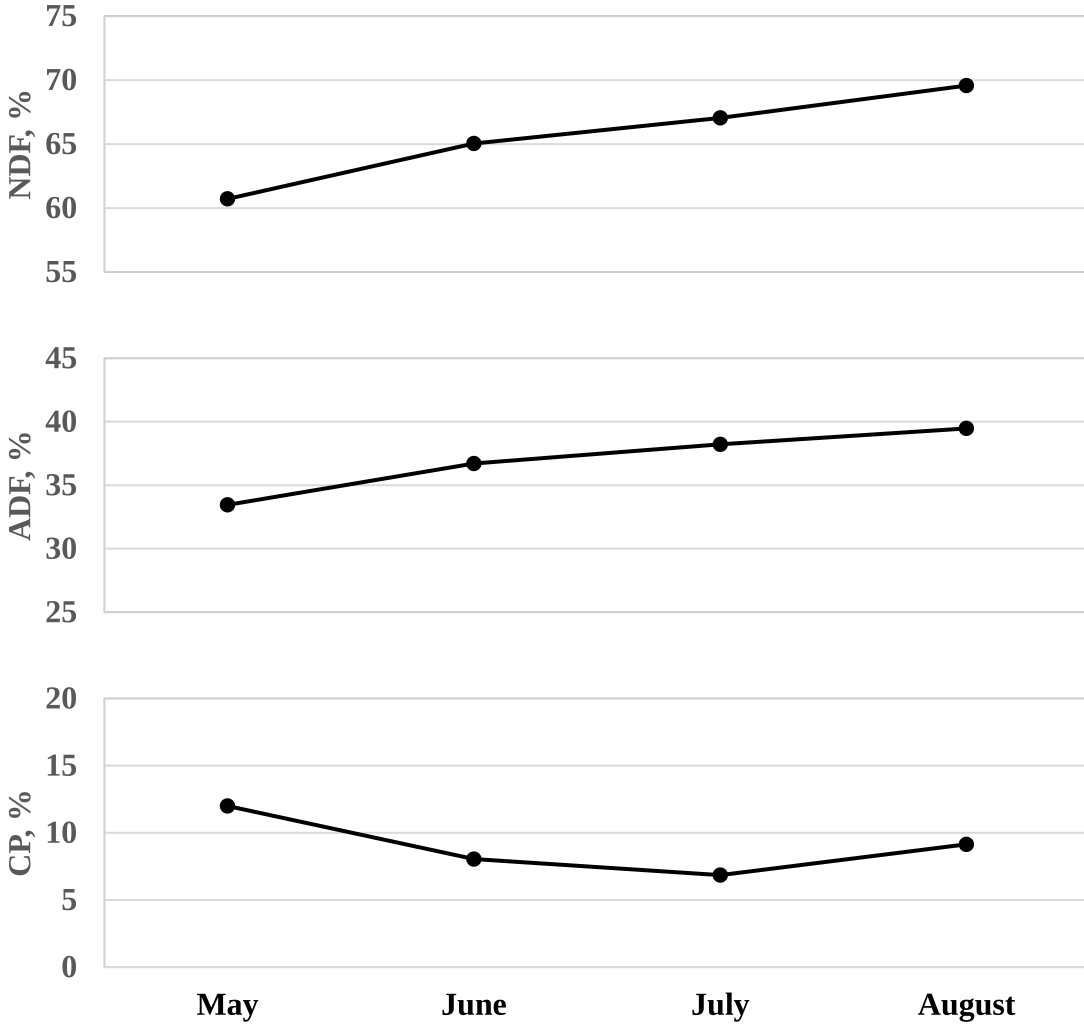

Figure 1. Forage quality [percentage neutral detergent fiber (NDF), acid detergent fiber (ADF), and crude protein (CP)] of endophyte-infected fescue (*Festuca arundinacea*), white clover (*Tri-folium repens*), and red clover (*Tri-folium pretense*) pastures from May 2018 to August 2018. Samples were collected as cattle rotated pastures and were composited on a monthly basis.

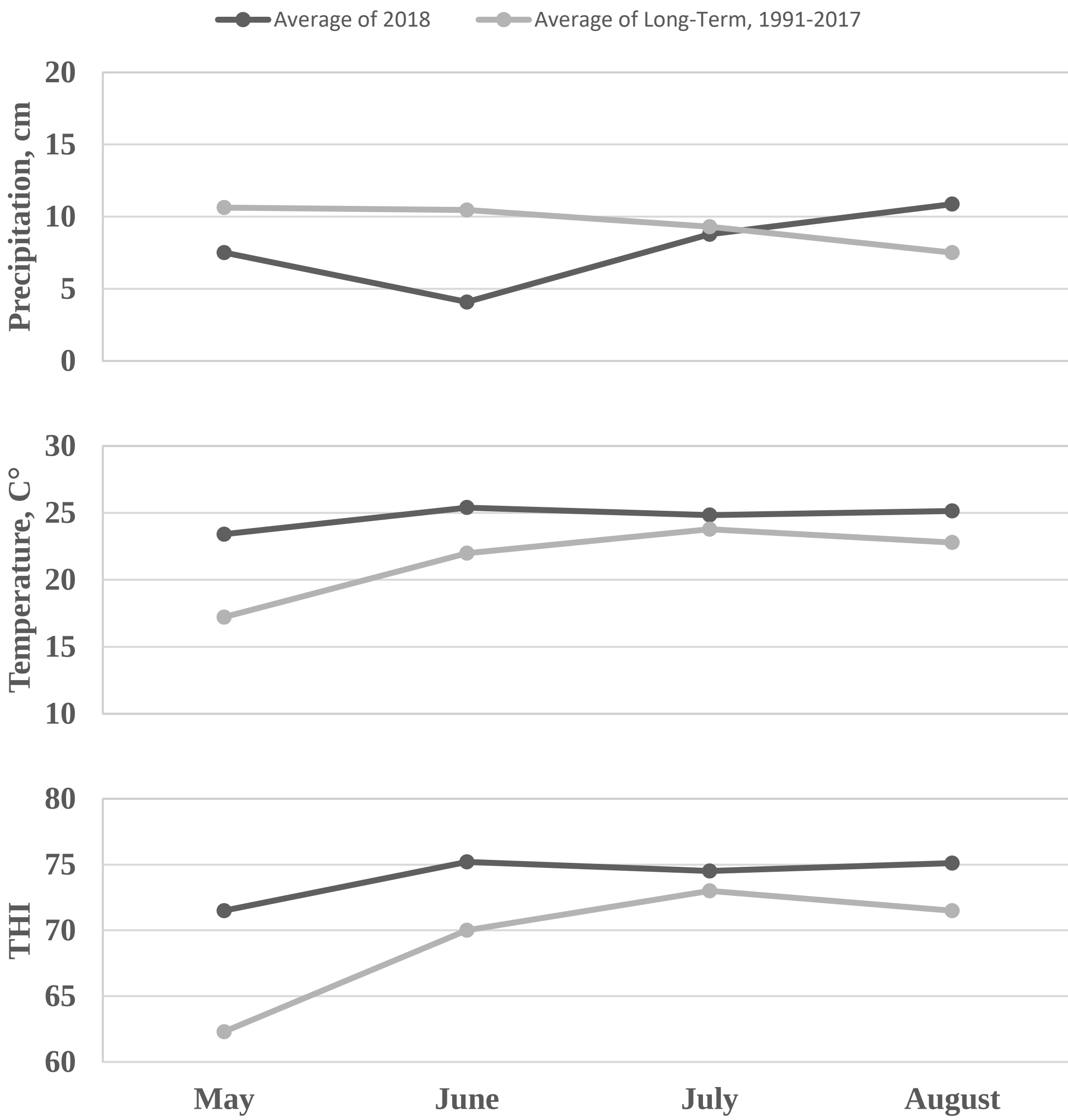

Figure 2. Comparison of precipitation (cm), temperature (C°), and temperature and humidity index (THI) at ORR Beef and Research Center from May 2018 to August 2018. Data were collected from Water and Atmospheric Resources Monitoring Program. Illinois Climate Network. (2015). Illinois State Water Survey, 2204 Griffith Drive, Champaign, IL 61820-7495. https://dx.doi.org/10.13012/J8MW2F2Q,.

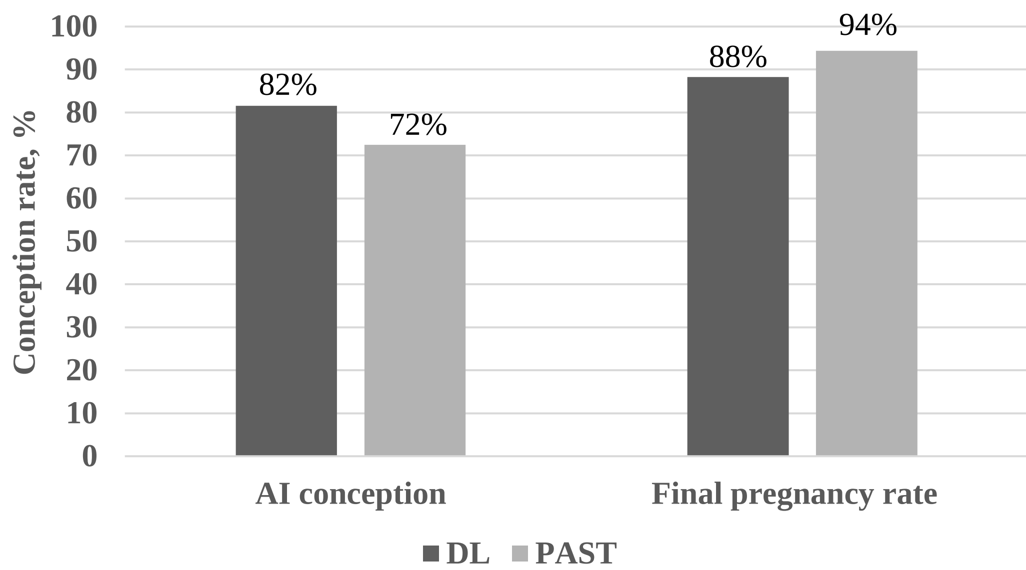

Figure 3. The effect of drylot (DL) and pasture (PAST) treatment on artificial conception rate and final pregnancy rate ($P \geq 0.34$).

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